Study of textures of zirconium base alloys by neutron and X-ray diffraction

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Introduction

Neutron and X-ray diffraction is a very powerful tool in texture analysis of zirconium base alloys used in nuclear technique [1]. Textures of five samples (labeled as ZZ13, ZZ14, ZZ19, ZZ16 and ZZ17) were investigated by using pole figures and inverse pole figures.

The pole figure measurement were performed at a θ-θ X'Pert PRO diffractometer with CrKα radiation. Pole figures for planes 010 (2θ = 48.4°), 002 (2θ = 53.1°), 011 (2θ = 55.6°) and 110 (2θ = 90.4°) were measured.

The inverse pole figure measurements were performed at diffractometer KSN-2 at Laboratory of Neutron Diffraction, Department of Solid State Engineering, Faculty of Nuclear Sciences and Physical Engineering, CTU in Prague. The wavelength used was λ = 0.1362 nm. The data were processed using software packages X'Pert Texture, HEXAL [2] and GSAS [3].

Samples

The texture measurements of five samples (labeled as ZZ13, ZZ14, ZZ19, ZZ16 and ZZ17) were performed at the diffractometer KSN-2 at Laboratory of Neutron Diffraction, Department of Solid State Engineering, Faculty of Nuclear Sciences and Physical Engineering using the TG-1 texture goniometer with automatic data collection [2]. The monochromatic neutrons having wavelength 0.1362 nm were used.

Fig. 1 shows shape and dimensions of samples. Four samples (ZZ14, ZZ19, ZZ16 and ZZ17) were deformed by uniaxial tension by using mechanical testing system ISNTRON 5882. Tab. 1 shows parameters of the experiment. Structure of the initial (non-deformed by uniaxial tension) sample ZZ13 observed by using light microscope Zeiss Axio Imager ZM1 and back-reflection X-ray diffraction patterns are in Fig. 2.

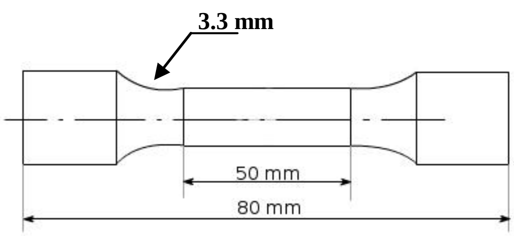

Figure 1. Shape and dimensions of ZZ samples.

Table 1. Parameters of uniaxial tension experiment.

Sample	ε [%]	σ [MPa]
ZZ14	6	121
ZZ19	10	124
ZZ16	15	134
ZZ17	20	146

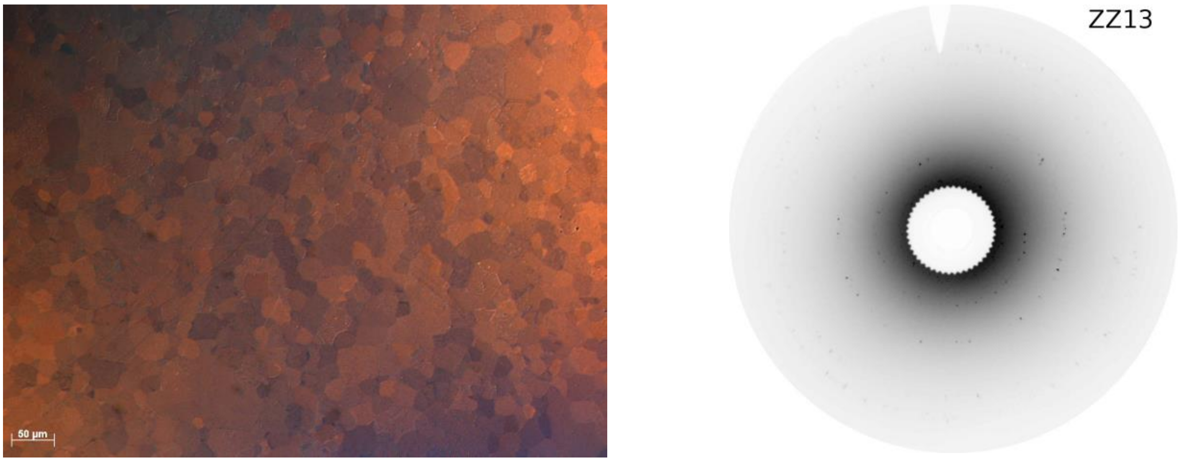

Figure 2. Structure of initial sample ZZ13 observed by light microscope Zeiss Axio Imager ZM1 (left). Back-reflection X-ray diffraction pattern (right)

Inverse pole figures

The intensity ratios $p_{hkl,q}$ were calculated by Mueller formula for (100), (002), (101), (102), (110), (103), (112) and (201) reflections for directions q = TD, ND, RD. In Tab. 2 are calculated pole densities for planes (100), (002) and (110).

Table 2. Calculated inverse pole figures of ZZ samples.

Sample	**ZZ13**	**ZZ14**	**ZZ19**	**ZZ16**	**ZZ17**
$\mathbf{p_{002,\,TD}}$	1.3	1.9	1.8	2.1	2.3
$\mathbf{p_{002,\,ND}}$	2.8	2.7	2.6	2.8	3.1
$\mathbf{p_{002,\,RD}}$	0.1	0.1	0.1	0	0
$\mathbf{p_{100,\,TD}}$	1.0	0.7	0.5	0.6	0.5
$\mathbf{p_{100,\,ND}}$	0.4	0.5	0.4	0.5	0.4
$\mathbf{p_{100,\,RD}}$	2.6	3.2	4.3	3.8	4.0
$\mathbf{p_{110,\,TD}}$	0.8	0.8	0.7	0.7	0.9
$\mathbf{p_{110,\,ND}}$	0.21	0.3	0.2	0.4	0.4
$\mathbf{p_{110,\,RD}}$	3.1	2.6	2.8	2.2	1.9

Pole figures

Pole figures are in Fig. 3.

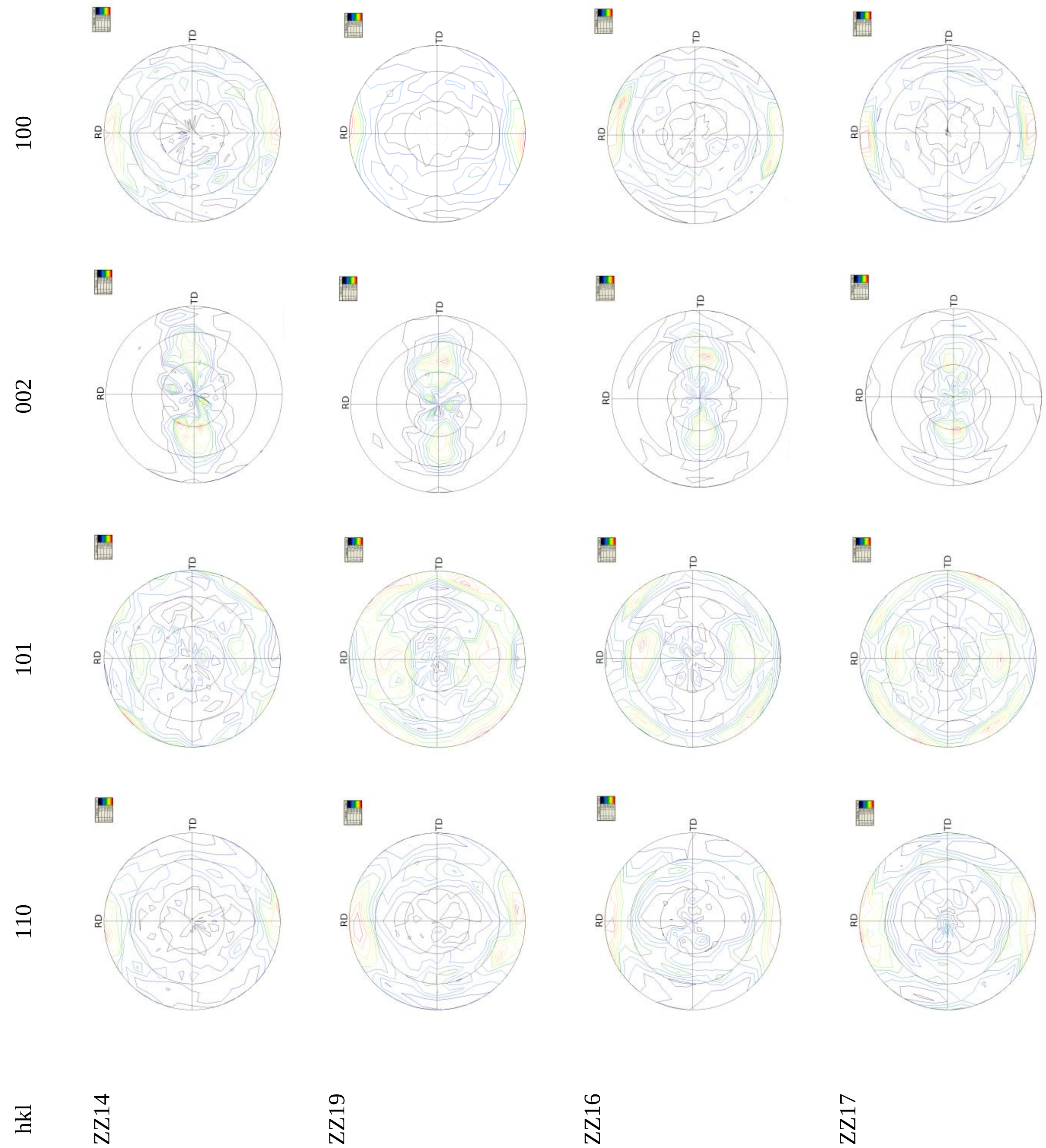

Figure 3. Pole figures of zirconium samples ZZ14, ZZ19, ZZ16 and ZZ17. System of coordinates is represented by ND, RD, and TD.

Discussion and Conclusions

Our results can be summarized as follows:

- Samples prefer orientation of planes (100) and (110) perpendicular to rolling direction.
- The position of the basal poles is tilted by 30° from the normal direction (ND) toward the transverse direction (TD).
- Samples prefer orientation of planes (102) and (103) perpendicular to normal direction
- Level of resulting texture increases with deformation.

References

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